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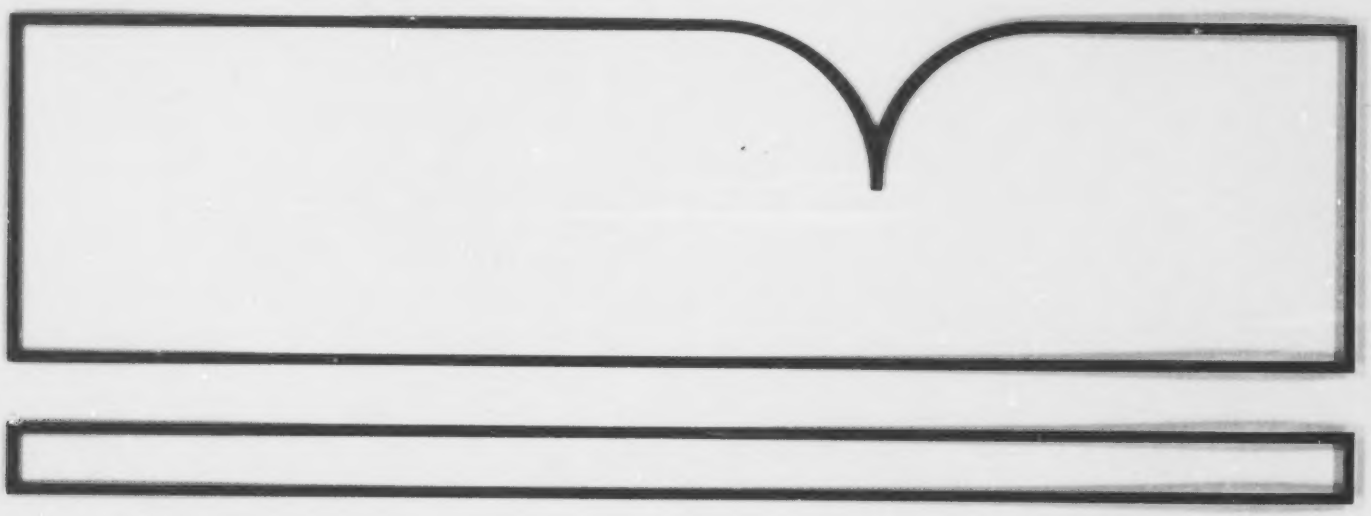

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THE SCIENTIFIC AND TECHNICAL ISSUES FACING POST-1987 OZONE CONTROL STRATEGIES: A Conference Summary

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16. ABSTRACT

This paper summarizes the presentations given at an International Specialty Conference on tropospheric ozone and ozone control strategies. The conference, sponsored by the Air Pollution Control Association, was held in Hartford, Connecticut on November 16-19, 1987. Because many metropolitan areas in the US failed to meet the National Ambient Air Quality Standard (NAAQS) for ozone by the December 31, 1987 deadline despite massive control programs, and because consideration is being given to tightening and/or changing the form of the current NAAQS, the conference was extremely timely. The conference opened with a plenary session, which focused on the questions why have we not achieved the standard and where do we go from here. Following the plenary session, concurrent sets of sessions were held for the remainder of the conference. One set of sessions focused on volatile organic carbon control strategies including low solvent coating, add-on control techniques and monitoring for compliance. A second set of sessions dealt with the scientific aspects of the issue and included: chemical mechanisms, urban- and regional-scale modeling, field studies and data analysis. The highlights of the conference are summarized.

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This paper summarizes the presentations given at an International Specialty Conference on tropospheric ozone and ozone control strategies. The conference, sponsored by the Air Pollution Control Association, was held in Hartford, Connecticut on November 16-19, 1987.

Because many metropolitan areas in the US failed to meet the National Ambient Air Quality Standard (NAAQS) for ozone (O_3) by the December 31, 1987 deadline despite massive control programs, and because consideration is being given to tightening and/or changing the form of the current NAAQS, the

conference was extremely timely. The conference opened with a plenary session which focused on the questions why have we not achieved the standard and where do we go from here. Following the plenary session, concurrent sets of sessions were held for the remainder of the conference. One set of sessions focused on volatile organic carbon (VOC) control strategies including low solvent coatings, add-on control techniques and monitoring for compliance. A second set of sessions dealt with the scientific aspects of the issue and included: chemical mechanisms, urban- and regional-scale modeling, field studies and data analysis. The highlights of the conference are summarized below. The papers that are submitted and successfully complete the peer-review process will be published together in an APCA Transactions.[1]

PLENARY SESSION

The plenary session set the tone for the meeting. The speakers were asked to present their views on why large portions of the country had not attained the ozone standard, and what should be done in the future to attain the National Ambient Air Quality Standard (NAAQS). Leslie Ritts, Counsel to National Environmental Development Association's Clean Air Act Project (NEDA/CAAP), William Becker from STAPPA/ALAPCO (State and Territorial Air Pollution Program Administrators and Association of Local Air Pollution Control Officials), Michael Bradley from the Northeast States for Coordinated Air Use Management (NESCAUM), and Betsy Johnson of the Sierra Club presented their views. There was agreement that an ozone problem exists. There was, however, differing views on the severity of the problem and the measures which needed to be implemented. Following these presentations Nicholas Gallopoulos from General Motors Research Laboratories (GMR) gave a scientist's perspective on the status of the science of ozone control.

Ritts[2], representing NEDA/CAAP, said her group acknowledges that there is a problem. She said that the proposal for a revised ozone policy, which was to be announced later in the day by EPA Administrator Lee Thomas was reasonable, but she was concerned over the draft bills presently being marked up in Congress. She felt these draft bills were overly prescriptive, proposed deadlines for attainment which the states could not meet, and would stifle modernization of the industrial base.

Becker[3] cited several reasons for widespread ozone nonattainment. He acknowledged that some areas did not submit adequate state implementation plans (SIPs) and that some areas had not adequately implemented their SIPs. He also expressed concern with the quality of the models available when the SIPs were being developed (1978 through 1982). The States believe that the models underestimated the reductions necessary, and that there were not adequate mechanisms for accounting for transport of ozone into the nonattainment area from upwind areas. For the future, STAPPA/ALAPCO proposed that: 1) the States need to increase efforts to get maximum benefits from the ozone controls currently in place; 2) Congress should require the Federal Environmental Protection Agency (EPA) to develop and implement a set of federal control measures (such as architectural coatings and consumer commercial solvent emission limits); 3) controls should be required on all sources greater than 50 tons per year; and 4) sanctions should be applied for failure to implement, not failure to attain. STAPPA/ALAPCO feels that the EPA strategy does not go far enough to prescribe measures that the States must implement.

Bradley[4] presented the views of the Northeast States. He said that the primary reason why the Northeast States did not attain the O_3 standard was because of the transport of ozone and its precursors. He said that EPA must continue to support work on the Regional Oxidant Model (ROM) so that better tools will be available to predict impacts and reduction requirements over the entire East Coast corridor (Virginia to Maine). NESCAUM does not support the EPA approach. They would prefer a technology based approach, with mandated control measures, equal treatment for all sources in all areas, and a much greater EPA national program. They want EPA to promulgate more stringent light- and heavy-duty tailpipe standards, onboard vapor recovery, stricter gasoline volatility rules, and regulations to reduce reactive consumer and commercial solvents emissions. They also suggested that EPA require tougher inspection/maintenance (I/M) requirements, and that the new car certification programs be tightened to ensure lower emissions from new cars.

Johnson[5] criticized the States and EPA for not doing enough to solve the problem. The Sierra Club advocates setting tougher national emission controls on cars, buses and trucks, adopting stricter I/M requirements, defining the

problem and solutions on the East Coast as a regional problem, requiring controls in all areas contributing to the nonattainment problem, prescribing control requirements for many VOC sources presently uncontrolled, and adequate funding to study and implement the measures that will be required.

The session ended with Gallopoulos[6] proposing a national cooperative research coalition which would involve industry, government and academia to help better define and address the problem. He highlighted some of the many uncertainties associated with emission inventories, the role of natural ozone, and the mathematical models and chemistry used to calculate impacts. He said that these uncertainties are compounded by the limited monitoring network for ozone, and the even more limited monitoring data for the precursor pollutants, (reactive VOC and oxides of nitrogen [NO_x]). His message was clear — we must improve our knowledge if we want to solve the problem, and the solution will take money and a concerted effort from all groups (industry, government, and academia) to be successful.

CONTROL STRATEGIES AND TECHNIQUES

Post-87 Ozone SIP Requirements

This session was designed so EPA representatives could present the emerging Post-87 EPA policy on ozone attainment plans which EPA Administrator Lee Thomas announced from Washington on the first day of the conference.

Nicholson[7] gave a summary of the proposed Post-87 ozone policy. He described the timing for the inventory, SIP submittal and attainment demonstration, and he discussed the requirements for areas which could attain in the near term vs. the long term. Nicholson indicated that the proposed policy includes some federally implemented controls (Reid Vapor Pressure [RVP], onboard refueling controls and additional limits on emissions from new cars and trucks) as well as state-initiated controls. The policy was designed to provide the States with increased flexibility in developing their plans, but requires each area to achieve a 3% reduction each year.

Misenheimer[8] then discussed the emission inventory requirements for the Post-87 SIPs. He explained that the inventory will include not only VOC, NO_x, but also carbon monoxide (CO) emissions. He described some of the new emission factors which are being developed for VOC source categories not previously included in inventories, such as publicly-owned treatment works (POTW's) and waste treatment, storage and disposal facilities (TSDF's).

Meyer[9] summarized EPA procedures for modeling analysis required as part of the Post-87 SIP submittal. He discussed general issues such as how to treat temperature, precursor transport, NO_x controls, and chemical mechanisms. He also discussed model specific issues. For the Empirical Kinetic Modeling Approach (EKMA) model he recommended that the submittal should:

1. identify the five highest daily maximum days,
2. discuss the likelihood that the Metropolitan Statistical Area (MSA) contributed to the violation,
3. replace days with overwhelming transport with other violation days,
4. evaluate model results for the base case,
5. determine site-specific control estimates, and
6. identify the control requirement for the entire MSA.

Meyer also discussed procedures to follow when using the Urban Airshed Model (UAM). He included information on:

1. selection of prototypical scenarios,
2. evaluation model performance,
3. simulation procedures,
4. techniques to revise emissions to reflect various control strategies, and
5. identification of procedures to determine when you have demonstrated attainment.

Johnson[10] discussed EPA efforts to evaluate the quality of existing control measures (i.e., how well the States have written existing regulations) and additionally, the performance of the States enforcing these regulations. He indicated that there are still some States that do not have all the required regulations and some states have less-than-ideal regulations. In

addition, he said that we are a long way from knowing how well the States are enforcing the regulations in the SIPs. Some of the reasons for the quantity and quality of the regulation on the books were identified and Johnson explained where the agency stands on the enforcement evaluation, which is commonly referred to as "rule effectiveness" evaluation.

Johnson[11] then discussed the EPA's proposed policy on measuring progress towards attainment of the standard. In the 1979 and 1982 policies this was referred to as "Reasonable Further Progress" or RFP. He described the three parts to RFP which will be required in the Post-87 SIPs: aggressive tracking, evaluation of rule effectiveness, and periodic updates of the attainment demonstration. He also outlined the new maintenance procedures which each area must adopt before EPA will redesignate an area from nonattainment to attainment.

POTENTIAL FUTURE VOC CONTROL MEASURES

This session was designed to present information on new or emerging control requirements. Twaddell[12] began with a discussion of the modeling that was done to project 1988 attainment of the New York, New Jersey, Connecticut domain. The results indicated that even with an 8% additional reduction in VOC from extraordinary measures, (architectural coatings, auto refinishing, consumer/commercial solvents and adoption of small sources RACT [reasonable available control technology]), the UAM projected little additional benefit in ambient ozone levels.

Miles-Mclean[13] then discussed the projected results of strategies envisioned for a Post-87 ozone control strategy for the New York, New Jersey and Connecticut nonattainment area. The strategies included gasoline volatility at 9.0 pounds per square inch (psi), fully implemented on-board canister program, and enhanced I/M. With these additional controls, the peak levels in Connecticut are still predicted to exceed the ozone NAAQS using the UAM.

The Transportation Control Measures developed for Santa Barbara County were then discussed by Gschwandtner[14]. She described the 15 categories

considered (such as area-wide ride sharing, traffic flow improvements, and high occupancy vehicle lanes). The analysis included the potential reduction, cost, implementation time frame and other impacts of adopting each measure.

Seidman[15] described the New England States' proposal to reduce the average RVP from 11.5 psi to 8.0 psi. The strategy will reduce VOC emissions by approximately 100,000 tons per year. Her results indicate that the strategy is about as cost effective as other strategies being considered, it would require little additional state resources, and it could be implemented within a few months.

The use of electron beam technology was discussed by Williams[16]. He described recent experiences in Germany where the electron beam was used to reduce NO_x using ammonia injection in a wet-scrubbed flue gas from a coal-fired power plant. The system proved effective in reducing not only NO_x, but also sulfur dioxide (SO_2), VOC, hydrofluoric acid, dioxins, furans, polyaromatic hydrocarbons (PAH) and other toxic compounds.

Baamonde[17] discussed the development of an inventory of VOC emissions from publicly-owned treatment works (POTWs) in New York and New Jersey. POTW's account for more than 10,000 tons of VOC per year. The author used results from ambient monitoring to validate their estimating techniques, but acknowledged the difficulties in developing good estimates because of the general lack of information on the concentrations of VOC in the influent of the POTW's.

CONTROL TECHNIQUES

This session included papers on control techniques for source categories regulated in the 1979 and 1982 SIPs. Holzman[18] discussed an alternative emission reduction plan (bubble) for a source in Connecticut. The bubble plan uses the excess emission reductions achieved from a coating line equipped with a fume incinerator to offset emissions from an uncontrolled line.

Clark[19] gave an overview of state regulations and control requirements for sources which do not have reasonable available control technology (RACT)

defined through an EPA published Control Techniques Guideline (CTG) Document. This presentation provided a source of information exchange on state regulatory requirements.

Hendenhag[20] then discussed the control of VOC through incineration and the factors influencing destruction efficiency. He reviewed both thermal and catalytic incinerators. In both types, retention time and temperature are the two key factors. Hendenhag[20] emphasized that heat recovery is an important cost consideration when evaluating incineration, and he reviewed both recuperative and regenerative heat exchangers.

Lee[21] discussed compliance at a large appliance surface coating facility through the use of high-solids paints. He described a new state-of-the-art, fully automated system used in Nevada. It includes an advanced metal cleaning and phosphating system, paint filtration and temperature regulating systems, energy recovery from a fume incinerator, and a centralized computer monitoring system. The system appears applicable to any metal parts used for large appliance or metal furniture.

Kenson[22] discussed a system developed in Japan called KPR designed to control emissions from automobile surface coating spray booths. He reported the results from a KPR installed line and compares the economics of this system to other control techniques.

Altay and Reddy[23] discussed various techniques used by sources to achieve VOC emission reductions. They reported that the most widely used add-on controls are thermal and catalytic incineration. They also discussed emission trading and summarized the US EPA emission trading policy.

James[24] discussed Rhode Island's program which encourages conversion to low VOC/high solids coatings. He described the emission reductions achieved through case studies. Reductions were achieved despite an expansion in the New England economy.

Yarrington[25] described a technique to regenerate catalysts using chemical cleaning procedures. He identified materials that are detrimental to catalyst

performance and provided laboratory results of the cleaning effectiveness. Industrial applications for chemical cleaning were summarized along with actual case histories of commercial installations.

MONITORING COMPLIANCE AND COMPLIANCE TECHNIQUES

Crumpler[26] described some of the practical engineering problems associated with measuring capture efficiency at a facility. He then went on to describe a technique to enclose the equipment being tested. The talk described the limitations of the technique and identified some of the problems which lead to erroneous results. Elter[27] then discussed a test case where the system was used in the field. The results indicate that the enclosure system is feasible. Testing of VOC concentrations for various coatings under controlled operating conditions and excess air leakage were discussed.

A semi-continuous gas chromatography technique to measure VOC in a gas stream was described by Frecker.[28] The system uses a modified Method 18 on-site gas chromatography with direct sample injection.

Palmisano[29] discussed the use of bubbles to allow sources to comply through averaging emissions on several process lines. He explained the economic advantages of bubbles and the need for regulatory agencies to accept this technique as a way to provide companies with an incentive to develop lower solvent coatings.

Work[30] described some of the problems involved with the RFP tracking system used in Region IX. The author presented results from the San Joaquin County, the San Francisco Bay area and the Los Angeles area. One of the most perplexing problems was accounting for year-to-year changes in approved emission factors. He also raised questions about the use of the data. For example, if an area is not on RFP, how should the agency respond? Should EPA call for a SIP revision, work informally with the area, or should there be some more formal procedures short of a SIP call? Many questions were raised and the need for consistency was a common theme.

Salman[31] discussed some of the problems associated with measuring transfer efficiency in automobile paint spray booths. He described the typical spray booth operation and procedures being developed by EPA to measure transfer efficiency.

SCIENTIFIC ASPECTS (ATMOSPHERIC STUDIES)

Chemical Mechanism Development

The two most advanced and widely used chemical mechanisms in photochemical modeling today are the Carter-Atkinson-Lurmann-Lloyd (CALL) and the Carbon Bond IV (CB-IV) mechanisms. The former was developed jointly by scientists at the University of California - Riverside and Environmental Research and Technology, Inc. (ERT), while the latter was developed by Systems Applications, Inc. (SAI).

Lurmann[32] described the CALL chemical reaction mechanism, a technique used to evaluate the mechanism with smog-chamber data, and the results of that evaluation. In general, the mechanism predicted the rate of NO_x oxidation and the maximum O_3 concentration within ±30% for a large number of single organic-NO_x experiments and organic mixture-NO_x experiments. For a surrogate ambient air mixture and automobile exhaust, the average errors were ±23% and ±15%, respectively.

Using a version of the CALL reaction mechanism, Carter[33] conducted model simulations to demonstrate a method that determines the relative O_3 formation potential of various organic compounds and mixtures based on OH reactivity. Not surprisingly, he found that the relative formation potential is not a constant but depends on the nature of the reaction mechanism and on the nature of the environment into which the compounds are emitted. The most important environmental factor was the VOC/NO_x ratio. At very high ratios, the relative formation potential decreased significantly for all VOC compounds examined. One compound he examined in more detail was methanol which is of particular interest because it is being considered as an alternate fuel for motor vehicles. His results show that the relative O_3 formation potential is lower

for methanol emissions providing the ambient VOC/NO_x is low and formaldehyde emissions are low.

Since 1976, SAI has been developing, testing and improving the carbon-bond mechanism. Gery[34] presented a historical perspective of this process and described the latest version, the CB-IV. In a companion paper, Hogo[35] discussed the incorporation of the CB-IV into EKMA to produce the Ozone Isopleth Plotting Package (OZIPM-4) which will be used by most urban areas in preparing their post-87 SIP's. Hogo also discussed the results of a sensitivity analysis of the EKMA (empirical kinetic modeling approach) input parameters on VOC control requirements. This analysis revealed that both the precursor concentration aloft and the mixing height can have significant effects on the calculated VOC control requirements. In many urban areas, NO_x reductions may require greater VOC control requirements, and in areas where CO concentrations are high compared to VOC concentrations, CO may play a significant role in O_3 formation.

Jeffries[36] presented a novel approach for testing chemical mechanisms against numerous smog chamber simulations. The approach is based on employing an "expert system" to categorize the numerous smog chamber simulations according to similar experimental conditions. Using the approach to test the ethene mechanisms used in the CALL and CB-IV schemes, he concluded that some aspect of the ethene chemistry is missing in both schemes.

In a second paper, Jeffries[37] compared the VOC control requirements calculated using both the CALL and CB-IV mechanisms in EKMA. A major conclusion from this work was that both mechanisms produced similar control requirements with the same hydrocarbon default fractions. Further, the differences in control requirements due to choosing different default mixes are greater than the differences in the predictions of the two mechanisms, thus emphasizing the need to accurately define the organic mix.

Urban-Scale Modeling

Two papers were presented that described the application of the UAM to Kern County, CA. SAI[38] described the UAM and showed that the discrepancy

between the low emissions VOC/NO_x ratio and the high measured ambient ratio in Kern County was resolved when the UAM was applied with sufficient vertical resolution to resolve NO_x emissions in the nighttime ground-based inversion layer. Significant wind shear at night caused buoyant plume NO_x emissions to travel aloft in a different direction than the surface-based VOC emissions. Croes[39] discussed an analysis of the O_3 nonattainment problem in Kern County, CA. In the 1979 SIP, EKMA predicted compliance by 1982; however, compliance is still not in sight. Consequently, the UAM was applied to Kern Co. to see if the reasons for EKMA's poor performance could be deduced. It was concluded that because Kern Co. has more than one distinct source region, each with very different VOC/NO_x mixes, EKMA was an inappropriate choice because of its inability to resolve disparate source regions.

The UAM was also applied to the greater New York Metropolitan Area encompassing parts of northern New Jersey and Connecticut for several different emissions and initial condition scenarios as part of the Oxidant Modeling for the New York Metropolitan Area Project (OMNYMAP).[40] The UAM showed O_3 violations in the area even when the emissions were turned off, thus indicating the importance of ozone and precursor inflow to the area. Ozone NAAQS violations also occurred from initial conditions and local emissions with inflow concentrations set to background values, suggesting the need to control emissions both in local and upwind areas to reduce New York Metropolitan area O_3 violations.

Two papers discussed the regulatory environment for application of the UAM. In the first, Liu[41] addressed several major issues related to regulatory applications of the model, including size and location of domain, selection of episodes, construction of a 3-D wind field, selection and analysis of specific control measures, and others. He used the LA basin in California as his example in discussing the issues. In the second paper, Haney[42] presented a plan for using the UAM for air quality analyses in support of New Jersey's post-1987 ozone plan. The objective of the analysis is to determine to what extent future controls on ozone precursors within New Jersey and upwind States may affect ozone levels within NJ and in downwind states.

Regional-Scale Modeling

Lamb[43] presented some preliminary results from the EPA Regional Oxidant Model (ROM) which is an Eulerian, episodic model that utilizes the CB-IV chemical mechanism. The model is applied over an area of 1200 x 800 km in the Northeast. Some of the major findings that he reported follow. 1) In all areas where the daily maximum exceeds 120 ppb, the O_3 is generated anew each day from imported and locally emitted precursors. Net daily import of O_3 occurs only in those areas remote from major NO_x and VOC source areas or within major NO_x source complexes. 2) During the day, the average lifetime of O_3 within 50 miles downwind of major sources is only ~2 hours. Between 50 and 100 km, the lifetime is ~2-4 hours while at greater distances it increases from 4-12 hours. At night, the lifetime is generally an order of magnitude greater. 3) Projected VOC emissions reductions result in reduced rates of O_3 generation in urban areas, but can cause slightly increased levels of production rates in rural areas.

The RTM-III is SAI's regional transport model which also incorporates the CB-IV chemical mechanism. Morris[44] described the model and showed the results when the model was applied to three very different geographical areas: western Europe, the eastern US, and the California Central Valley. These three applications resulted in over 14,000 comparisons with actual ambient measurements, and in general, over all hours of data, model predictions were within 10% of the measurements. However, peak daytime values were generally underpredicted.

Two papers were presented that described a regional model being developed at Harvard University.[45,46] Unlike EPA's ROM and SAI's RTM-III episodic models, the Harvard model simulates the mean O_3 climatology over North America using meteorology prescribed by the output of a general circulation model. Because spatial resolution in such a model is limited by computational cost, a large grid scale (400 x 480 km) is used. With such large grids, the effects of large local NO_x emissions are not adequately assimilated and large overpredictions of O_3 result. To eliminate this overprediction, a plume model which divides the 400 x 480 km region into boxes representing rural air, urban

plumes, and power plant plumes was incorporated. Preliminary results of the combined model appear reasonable.

Liu[47] presented the results of a three-dimensional modeling study of O_3 formation over the western US. His model has 60 x 60 km horizontal resolution with 15 vertical levels. Transport winds are derived from the MM4 mesoscale meteorological model. The model assimilates anthropogenic emissions as well as natural hydrocarbon and NO_x emissions. The results show that anthropogenic emissions have a significant impact on the concentrations of O_3, NO_x, and H_2O_2 in the rural West. Ozone predictions from natural precursor sources only varied from 31-45 ppb.

Trainer[48] reported on a study in rural Scotia, PA where comprehensive measurements of gaseous species, including individual hydrocarbon species up to C_{10} (including the naturally emitted terpenes and isoprene), were made. The same three dimensional model used by Liu,[47] which includes isoprene chemistry, was then used to simulate the Scotia data. They found that most of the O_3, particularly on the highest O_3 days when the concentrations were $\geq$ 100 ppb, was due to the oxidation of isoprene. The results further indicated that the limiting precursor was anthropogenic NO_x.

Kleinman[49] reported on a study using a trajectory model with a linear description of hydrocarbon oxidation. It was used to simulate O_3 concentrations in the northeastern US. This study also indicated an important contribution from natural hydrocarbons to the observed O_3 concentrations. Fay[50] described the results of a long-range transport model for annual average NO_x concentrations. His model, which accounts separately for nearby and distant sources, predicts that the distant sources account for 30% or more of the total concentration at major metropolitan areas and nearly all the total outside these principal source areas.

Field Studies and Data Analysis

Fishman[51] and Vukovich[52] presented companion papers describing NASA's Total Ozone Measurement Spectrometer (TOMS), which is used to measure the total O_3 distribution in the atmosphere. Aboard a sun-synchronous, polar-

orbiting Nimbus 7 satellite, TOMS has been providing daily total O_3 distributions across the globe since 1978. Although the purpose of the measurements was to monitor the stratospheric component, the authors demonstrated that large-scale surface O_3 episodes in the eastern US could be discerned over the stratospheric component. Such data can and are being used to study the climatology of tropospheric O_3 in the eastern US. After examining the summertime O_3 climatology through 1981, the authors found anomalously high O_3 in the southern U.S. during the summer of 1980. They attributed this to a high pressure system which persisted over the middle and western portions of the Gulf of Mexico for most of the period. The persistence of such a system was not observed during the other years.

On a smaller regional scale, Rao[53] described a statistical analysis of O_3 data from the New York Metropolitan area. Using bootstrap and extreme value statistics, they concluded that the variability in O_3 due to the year-to-year variability in meteorology is within the range of concentration change produced by emission reductions to date.

Several papers examined O_3 trends. Kuntasal and Chang[54] examined the trends of O_3, NO_x, HC and CO in four areas in California: the San Francisco Bay Area, San Diego, the San Joaquin Valley, and the Sacramento Valley. The results for temperature-adjusted O_3 for the 1975-1984 period show San Francisco to be slightly increasing, San Diego and San Joaquin Valley increasing, and the Sacramento Valley decreasing. Burkhart and Hamjian[55] reported on O_3 trends in New England from 1980 through 1987. A slight downward, but not statistically significant, trend was noted. Much of the year-to-year variability could be explained by the number of days exceeding 90°F. Wackter and Bayly,[56] however, argue that there are statistically significant downward trends in Connecticut. VanArsdale et al.[57] presented a unique data base obtained from Waltham, MA. Since 1967, the Waltham Suburban Experiment Station has been operating a Mast total oxidant monitor. The oxidant trend, however, was unclear from the data collected there. In a final paper on trends, Balentine[58] reported that during the 1980's, VOC emissions have been reduced by about 40% in Houston but the O_3 has remained constant.

Kelly[59] reported the results of a 1985 field/outdoor-smog chamber study conducted in a suburban location in Warren, MI, which is typically downwind of Detroit in the summer. By filling the outdoor-smog chambers with early morning ambient air, and by spiking some of the bags with additional NO_x and/or HC, or by diluting the chambers with clean air, Kelly assessed the impact of various emission-alteration scenarios. His conclusion was that the Detroit Metro Area is in the NO_x-inhibition region and that an HC-reduction strategy is the only viable strategy for reducing maximum O_3 concentrations.

In another Michigan-based study, Fitzner and Lax[60] reported on O_3 data collected from an aircraft over southern Lake Michigan upwind of Muskegon, which experiences some of the highest O_3 concentrations in Michigan. They concluded that most, if not all, of Muskegon's violations were due to the arrival of urban plumes from areas on the southwestern shore of Lake Michigan.

In other data analyses papers, Baugues[61] examined the relationships between O_3 precursors and meteorological variables and O_3 at several cities on days when O_3 was equal to or greater than 0.12 ppm, while Yarbrough[62] proposed a methodology that could be used to identify rural, self-generating O_3 areas.

Alternative Air Quality Indicators

Because of recent concerns that chronic health and welfare effects may be occurring due to frequent, repeated exposures to less than 0.12 ppm concentrations of O_3, two papers were presented which examined the relationships between possible alternative forms of the standard and the present form. McCurdy[63] considered six different indices: 1) the present form, 2) the number of exceedances of the current standard, 3) the number of days in an O_3 season with 8-hour daily maximum average greater than 0.08 ppm, 4) the maximum monthly mean of 1-hour daily maximum concentrations, and 5) the maximum monthly mean of 8-hour daily maximum averages. He found significant correlations between all of the indices and concluded that the best surrogate for both the long- and short-term indicators was the monthly mean of the daily 1-hour maximum O_3 concentrations.

Berglund[64] evaluated the relative stringency of potential alternative forms of the O_3 standard, and in particular compared the present form with a daily 8-hour maximum of 0.10 ppm. He concluded that the adoption of the 8-hour standard, in addition to the current 1-hour standard, would be more stringent than the current standard alone. However, the attainment status of most areas would remain unaffected.

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